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UNPUBLISHED PRELIMINARY DATA

A 22-Gc Balanced Canonically Tuned Varactor Quadrupler with 50-mw Output Power

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SUMMARY

To the best of the authors' knowledge the varactor multiplier to be described in this paper is the first successful realization of a symmetric, multiple-diode varactor frequency multiplier at centimeter wavelengths. The quadrupler is capable of delivering a power output of more than 50 milliwatts at 22.2 Gc with an efficiency in excess of 13%.

The circuit is unique in several respects. First, separation of even and odd harmonic power into different parts of the circuit is inherently accomplished through the use of a two-varactor balanced arrangement which, in addition, increases the power-handling capability by a factor of two. Second, coaxial (i.e., non-dispersive) tuning is provided in the input, output and idler circuits. Third, a combination of waveguide and coaxial elements are utilized to achieve the desired separation of harmonic and fundamental power.

The broadband model of the quadrupler is shown in Figure 1. The coaxial structures serve as the idler (11.1 Gc) tuning adjustments while simultaneously providing short-circuits at the guide faces at 5.55 and 22.2 Gc, independent of the position of the idler tuning stubs. The third harmonic (16.65 Gc) is open-circuited at the input port by a quarter-wave series trap. The output is tuned and matched to the load with a sliding backshort and an E-H tuner (not shown) and then further filtered with a simple cavity filter (to insure that all the indicated output power is at 22.2 Gc). Input tuning is provided by coaxial, double-stub tuners. The diodes are individually biased from 1000 Ω ten-turn potentiometers supplied with 12 volts.

The power output and efficiency of the quadrupler is shown plotted versus the input power in Figure 2. Note that the efficiency rapidly climbs from 8% to over 10% for a 3 db input-power increase from 50 to 100 milliwatts and then levels off to a slow rise to 13.5% at 400 milliwatts input. Calculations indicated that the diodes begin to overdrive at less than 30 milliwatts input. The canonical tuning makes the adjustment of the multiplier particularly simple. Saddlepoints and other tuning anomalies are absent; in fact, with a very small sacrifice in efficiency, the quadrupler can be retuned for input powers ranging from 30 to 500 milliwatts with bias voltage adjustment alone.

Although the experimental quadrupler utilized overdriven graded-junction varactors (two matched, epitaxial GaAs varactors, type D5047B, supplied by Sylvania Electric Products, Woburn, Mass.), the theoretical results available on overdriven doublers [1,2] can be used to extrapolate from the existing abrupt-junction theory.[3] Assuming reasonable levels of idler loss and input-output circuit loss, the measured efficiency is in agreement with the theoretical efficiency. The overdrive ratio is very high (greater than 10:1) without appreciable conduction current (less than 1 ma/diode at 400 milliwatts).

The results verify the supposition that careful attention to design, coupled with symmetric-circuit techniques can remove much, if not all, of the necessity of having an "agile screwdriver" for successful operation of microwave varactor multipliers. The multiplier presented no surprises other than pleasant ones and proved tractable and spurious-free.

FIGURE 1

Partially exploded view of the 5.55 to 22.2 Gc balanced quadrupler. The two varactors are mounted across the guide and driven coaxially at the center point. The idlers are tuned individually by the two coaxial stubs.

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